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The causal impact of performance-based funding on university performance: quasi-experimental evidence from a policy in Russian higher education

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Abstract

In most countries implementing structural transformations in their higher education systems, a key goal of policymakers is to tie the amount of public funding to university performance. The present article analyses the Russian performance-based funding (PBF) reform to provide a quasi-experimental assessment of its effects on university performance. To evaluate the causal effect of PBF on university performance, we define the treatment and control groups by distinguishing universities on the basis of changes in their performance-based allocations and estimate the causal effect of the redistribution of public funds between universities as a result of PBF. Results indicate that the performance of universities is indeed affected by the extra funding generated by the reform, although heterogeneity is also at play. In the short term, the new policy has had an impact on the average national exam scores of enrollees showing that it has had encouraged universities to be more selective.

JEL classifications: I22, I23, I28

1. Introduction

In recent decades, many countries have promoted structural transformations of higher education (HE) systems in order to increase the accountability and performance of HE institutions (HEIs; Parker, 2011). HE expansion and marketization, together with falling amounts of available public funding due to fiscal pressure (Johnstone *et al.*, 1998), has forced national governments to reconsider existing funding principles. Negotiation processes have been replaced by mechanisms fostering a more productive and efficient provision of public services (Liefner, 2003; Agasisti and Pérez-Esparrells, 2010). Performance-based funding (PBF) has become a key instrument for aligning state interests, the amount of public funding allocated to universities, and their performance (Jongbloed and Vossensteyn, 2016; Jongbloed *et al.*, 2018).

Russia is no exception to this international trend, and the Russian government has launched a series of HE governance reforms over the past decade. Since 2012, it has promoted performance evaluation, transparent data use, and managerialism in order to enhance performance and accelerate institutional change (Platonova and Semyonov, 2018). One aspect of this reform that is particularly interesting in the context of the present article is the introduction in 2015 of new mechanisms for allocating public funding on the basis of university performance.

PBF mechanisms aim to improve different university activities, including retention rate, research performance, and quality assurance. The effects of such funding reforms have been studied in a series of academic papers that focus on university managerial behaviour (Jongbloed and Vossensteyn, 2001), system differentiation (Sörlin, 2007; Abankina *et al.*, 2018), and the growth of efficiency and productivity (Bolli *et al.*, 2016). However, research on the causal assessment of PBF on university performance is quite limited, mainly focusing on US experience (e.g. Hillman *et al.*, 2015; Umbricht *et al.*, 2017; Kelchen, 2018).

The introduction of PBF in Russia has given an understanding of the short-term effects of shifting funding rules on a number of university performance indicators. Since the introduction of the new policy, the bulk of public funding[1] has been allocated with the help of performance-oriented formulas. This makes public universities heavily dependent on the competitive mechanism of resource allocation. Such competition between universities arises, because the total amount of public funding hardly changes, while the PBF scheme relates university funding to performance. Therefore, HEIs have begun to improve their performance to compete for scarce resources. In the context of such policy, the scarcity of available resources has made some universities sustainably receive more public funding (i.e. *win out*) in the years after the introduction of PBF, while making others *lose out* under the new scheme (Abankina *et al.*, 2018). Given that all universities were made aware of the rules of resource distribution after the introduction of the reform and that the volume of resources distributed through this mechanism constituted a substantial part of university budgets, every university has had a strong incentive to change its behaviour over the subsequent period in order to maximize performance.

This article makes a quasi-experimental assessment of the effects of the redistribution of public funding due to the new funding mechanism based on university performance. Although all public universities are involved in the new funding mechanism, the causal effect of funding redistribution on university performance can be estimated by considering the allocation of extra public funding to some ('winning') universities as the treatment, and the winning universities as the treated group, and comparing them with their counterparts that did not experience changes in funding. More specifically, we shall focus on the effects of the funding change on university performance in the years immediately following reform implementation by answering the following research question: *Did the extra funding received by universities due to the PBF reform causally influence their performance in*

1 At least 60% or 37.7% of the total funding of public universities.

subsequent years? In other words, the effect analysed in this article is related to additional funding received by some HEIs. The effect of additional funding on performance level can be considered to be a direct consequence of PBF introduction. Therefore, the assessment made by this study can be interpreted as the causal effect of PBF reform on university performance.

The main institutional challenge for the causal assessment of such system-level reform is that it affects all universities alike, which makes the selection of a control group difficult. We solve this methodological problem by distinguishing universities on the basis of the amount of funding they receive under PBF. After selecting the treatment and control groups, we employ an innovative semiparametric difference-in-differences (DID) approach to assess the causal effect of the redistribution of public funds across universities. Although some studies have discussed the consequences of similar initiatives in other European countries (e.g. British Research Assessment Exercise—Elton, 2000), this is, to the best of our knowledge, the first study to assess the causal impact of PBF policy on HEI performance in the Russian context.

This article is organized as follows. Section 2 introduces the reader to the Russian PBF reform and provides details on the new funding mechanism. Section 3 presents a general overview of HE funding mechanisms with a particular emphasis on the rationale behind PBF policies and the assessment of their effects. Section 4 describes the data and econometric approach used in the study. Finally, the main results and their discussion are presented in Sections 5 and 6, respectively.

2. Policy background: HE funding in Russia

The budget of Russian public HEIs is composed of two main parts: (i) public funds allocated by the federal government[2] and (ii) private funds received from tuition fees and the commercialization of R&D. The state plays the dominant role in financing public HE in Russia. In 2018, public funding accounted for 59.3% of the total funding of the HE system (while 24.1% came from tuition fees, 12.3% from private institutional funding, and 4.3% from other sources). Russian HE is a dual-track system: 50.3% of students receive public funding, while 49.6% pay tuition fees.

Public funding also consists of several parts. The largest part of public funding comes from a subsidy for educational services distributed through the PBF mechanism. On average, it accounts for 37.7% (with a standard deviation of 10.9 percentage points (p. p.)) of the total funding of public universities.

Apart from PBF, there are other mechanisms through which universities receive additional public funding. In particular, during the 2010s, the government introduced several project funding mechanisms for HE such as the 5–100 Project excellence initiative. The annual project subsidy, however, does not exceed 2% of the annual federal budget for HEIs (Agasisti *et al.*, 2020). Nevertheless, only 21 out of almost 500 universities have been involved in this project, and so the PBF subsidy is the main source of public funding for most universities.

Historically, the main mechanism for allocating public funding between universities was based on negotiations between university managers and the Ministry of Education and

2 In general, the financing of higher education is a federal issue in Russia. In 2018, 95.1% of public HE funding came from the federal budget.

Science (MoES).[3] HEIs were financed according to their financial plans. The budgets of HEIs were divided into expenditure items, and universities received funding for each item separately. The funds, which were not spent during the year, could not be used during the next period.

In the 2010s, the Russian government started to reform public funding schemes for public sector organizations, including universities. The main idea of these reforms was to link the amount of public funding to the organizations' performance. In the case of universities, public funding for educational services was made dependent on the universities' performance and took into account the size of the student body and the amount of public funding per student (which makes the new funding performance-based, normative, and per capita at the same time).

The announced rationale for the new funding scheme was to assure the high quality and performance of universities and to make the allocation of public funding more transparent for stakeholders by enhancing the principle of accountability. Such funding policy was consistent with other technocratic statist management mechanisms of the 2010s, including MoES HEI Performance Monitoring, which led to the closure and reorganization of HEIs, and a set of stratifying projects for the development of a group of leading HEIs (Platonova and Semyonov, 2018).

The current normative per capita funding scheme involves several stages. First of all, the MoES specifies the total number of publicly funded places at universities in a given year for the whole national public HE system. This number is calculated using the normative approach of providing 800 publicly funded places per 10,000 population of 17- to 30-year-olds. Then, the Ministry collects university propositions about the number of students they can admit to each field of study and starts the formal procedure of distributing places across universities. This process is based on two sophisticated predefined formulas. The first formula determines the number of publicly funded places at each university: its result reflects a university's capacity to provide educational services. This capacity is calculated as the sum of performance indicators scaled by the rating of the performance indicators' values. The second formula determines the amount of public funding for each place. This amount comprises different types of university costs related to the provision of educational services ('basic standard costs') multiplied by correction coefficients. The basic standard cost of providing educational services consists of two groups of costs. The first group consists of costs directly associated with the payroll budget of the teaching, administrative and research staff, and other expenses. The second group of costs relates to general economic needs such as communication, transport, payroll for other (non-core) staff and public utilities. Standard costs are associated with running costs and do not cover capital expenditures. Standard costs depend on the field of study. These fields of study are classified into three groups on the basis of their basic standard costs (see Table 1). The standard costs for each group depend on the basic requirements for HEI facilities and resources, learning and teaching materials, and human resources.

The correction coefficients take the universities' performance and location into account. The performance coefficients depend on the value of the performance indicators. The

3 In 2018, the Ministry of Education and Science was reorganized and split into two separate authorities: the Ministry of Education, which is responsible for vocational education and the Ministry of Higher Education and Science, which deals with higher education and science.

Table 1. Three groups of basic standard costs by field of study[a]

Group characteristics	Group 1	Group 2	Group 3
Field of study	Humanities	Medicine	Engineering and Industrial sciences
	Mathematics	Agriculture	Medicine
	Teacher training	Social sciences	Arts and Cultures
	Social sciences	Arts and culture	
		Natural sciences	
		Engineering and Industrial sciences	
Basic standard cost (thousand roubles)			
Bachelor's programs	64.84	76.77	126.54
Master's programs	71.89	83.82	133.92

[a]According to the regulatory framework, programs within the same field of study may belong to different basic standard cost groups due to differences in education process and required equipment. For example, some programmes in medicine belong to group 2, and others to group 3.

Source: MoES database.

location coefficients are unique for every region of Russia. The complete list of indicators used in both formulas is presented in Table 2.

While the current funding mechanism contains elements of so-called ‘activity-based funding’ (the number of publicly funded places and the amount of public funding for each place), the total funding is highly dependent on the university’s measured performance (research productivity, R&D income, etc.). This shows that the real aim of the state is to stimulate universities to achieve positive outcomes, that is improve their performance. This makes the funding mechanism performance-oriented, which shows that the described policy can be viewed as a PBF policy.

It is crucial to note that universities had not been informed about the precise formulas and the set of indicators ahead of time. This implies that, if the government had had a different aim, it would have employed different performance indicators in the PBF, and the mechanism would have resulted in a different allocation of funds among universities. Moreover, although each university is responsible for its own performance and is able to control every performance indicator separately, the total score of a university in both formulas is determined by the aggregation of numerous indicators selected for the evaluation purpose, so that no institution could really predict its specific result in advance when the PBF system was just introduced. This information asymmetry also leads to the assumption that (i) every university had a strong incentive to maximize its performance and (ii) the *primary* gain or loss in terms of funding (in the year following PBF introduction) can be regarded as exogenous, and the effects of the redistribution in subsequent periods can be assessed in a causal way provided that a proper methodology is employed (see our approach in Section 4.2, which relaxes the parallel trend assumption and makes it possible to successfully deal with the endogeneity of the treatment in subsequent periods).

In order to provide a general description of the potential behaviour of universities under the PBF funding scheme, we make use of a theoretical framework presented in the Supplementary Appendix.

3. Related literature

Research on the effects of introducing PBF in various national contexts has yielded different evidence about the effectiveness of the new funding policies. However, the bulk of evidence concerns (i) the differences in studied PBF policies and the measurement of particular effects (academic outcomes, research outputs, access-related indicators), (ii) the extent to which universities are dependent on public funding in general and on the PBF in particular, and (iii) the extent to which PBF generates competition for scarce resources and therefore enhances HE system stratification.

In the case of Ohio and Tennessee, where PBF constitutes almost all state funding, no effect was found on the academic outcomes of universities, including total degrees and retention and graduation rates (Ward and Ost, 2020). When the PBF constitutes a minor share of the system’s funding, the results are quite mixed. Hillman *et al.* (2015) used DID to trace the effects of the introduction of PBF in Washington State and found a small short-term effect on retention rates and the associated degree productivity of local community colleges, which produced more short-term certificates after the policy reform. The latter are rewarded by the policy yet provide a lower return on education for graduates, making the reforms controversial. Using the same methodology, Kelchen (2018) found no significant effect of the PBF on underrepresented student enrolment in 4-year public colleges.

Table 2. Performance indicators employed in formula-based funding in Russian HE and their calculation methodology

Performance indicator	Use of indicator in the formula for		Calculation methodology
	Number of places	Standard cost per place	
Average national entrance exam score (for publicly funded places)	Yes (separately for the whole university and for individual programmes)	Yes (separately for publicly funded places and for tuition-funded places)	Ratio of the sum of products of the number of full-time students in publicly funded places and their individual average national entrance exam scores to the total number of full-time publicly funded places *Note*: (1) except employee-sponsored education, (2) the national entrance exam score of students admitted without entrance examinations (e.g. Olympiad winners) is taken as 100 (highest score)
Average national entrance exam score (for tuition-funded places)	Yes (separately for the whole university and for individual programmes)	Yes (separately for publicly funded places and for tuition-funded places)	Ratio of the sum of the products of the number of full-time students in tuition-funded places and their individual average national entrance exam scores to the total number of full-rime privately funded places *Note*: except employee-sponsored education
Number of publications in journals indexed by the Web of Science per 100 academic staff	Yes	Yes	Ratio of the number of publications of the university published during the reporting year in journals indexed by the Web of Science to the total number of academic staff multiplied by 100

(continued)

Table 2. Continued

Performance indicator	Use of indicator in the formula for		Calculation methodology
	Number of places	Standard cost per place	
Number of publications in journals indexed by Scopus per 100 academic staff	No	Yes	Ratio of the number of publications of the university published during the reporting year in journals indexed by Scopus to the total number of academic staff multiplied by 100
Total R&D income per academic staff member	Yes	No	Ratio of the total amount of income received from research and development activities during the reporting year to the total number of academic staff
R&D income from extra-budgetary sources per academic staff member	No	Yes	Ratio of the amount of extra-budgetary funds received from research and development activities during the reporting year to the total number of academic staff
Share of foreign students	Yes	No	Ratio of the number of foreign students in FTE to the total number of students in FTE
Ratio of the average monthly salary of university academic staff to the regional average monthly salary	Yes	No	Ratio of the university wage fund of academic staff to the average number of academic staff divided by 12 and by the average salary in the regional economy *Note*: except for civil contracts (independent contractor agreements)

Source: MoES decrees on the methodology of formulas calculation.

Similarly, Hillman *et al.* (2014) found no effect of the reform on the college completion rate in Pennsylvania. Using DID, Umbricht *et al.* (2017) found no increase in the number of graduates in Indiana due to the introduction of PBF.

With regard to research outputs in Finland, where PBF accounts for 13% of core HE funding, Mathies *et al.* (2020) demonstrated that the new mechanism and its increasing role in university budgets changed researchers' publication patterns and stimulated them to publish in journals of higher quality. In Slovakia, university research funding is dependent on PBF to the same extent as in Finland, and Pisár and Šipikal (2017) showed that the research output of HEIs increased by >30% over 6 years after the introduction of backward-looking PBF. However, this increase was comparable to the situation in Austria, where PBF is forward-looking yet constitutes up to 100% of the total recurrent funding, according to de Boer *et al.* (2015). Shin (2010) found that states which adopted PBF did not demonstrate a perceptible increase in university attraction of external research funding, noting that PBF constituted 6% of the overall HE funding across the universities in the sample.

Another group of academic contributions assesses PBF from the standpoint of system differentiation. Sörlin (2007) suggests that in many countries PBF has promoted vertical differentiation and specialization between universities, although the mechanism ensures horizontal diversity within the system. Abankina *et al.* (2018) conclude that in Russia PBF has contributed to an increase in university stratification in disposable financial resources, which in turn significantly affects the quality of education provided. Similar results were found in the USA (Favero and Rutherford, 2020).

This survey of empirical research on the effects of PBF introduction leads to several conclusions. First of all, most studies consider education and research performance of universities separately, while only a few studies take several HEI activities into account. Secondly, according to a systematic synthesis of relevant research in the USA (Ortagus *et al.*, 2020), the differences-in-differences was the main method used in 20 out of 52 existing studies in the field. Causal evidence on PBF introduction in other than US contexts is quite scarce. This article aims at providing such evidence for both the education and research activities of HEIs in the Russian context of backward-looking PBF that ensures the lion's share of state funding in the system.

4. Data and research design

4.1 Data sources

This article uses data from two different sources. The first is HEI Performance Monitoring, which provides university-level data on performance indicators between the 2014–5 and 2018–9 academic years. The second source of information on the amount of public funding comes from the MoES database. Financial data are available only for universities that are governed by the MoES, which restricts our sample to these institutions. While about approximately 300 universities are governed by the MoES, the financial data of only 241 universities is fully reported. Moreover, after the first stage of our study, we excluded 27 universities due to a lack of data on their performance. Thus, the final sample used in our empirical analysis includes 214 universities under MoES authority in 77 regions (out of 85 regions in Russia). Universities governed by the MoES have 68.5% of full-time equivalent (FTE) students of all public universities.

4.2 Research design

The main difficulty in evaluating the causal effect of PBF policy on university performance lies in the absence of a natural control group, as all HEIs are affected by the reform alike, and thus the use of a conventional DID approach is problematic. However, it is possible to estimate the effect of PBF by considering reform-induced extra public funding as the treatment and comparing the performance of universities that gained extra funding with those that did not. It must also be highlighted that, before 2015, universities were very heterogeneous in performance terms, with some universities performing much better than others. Better performers were more likely to obtain more funding in the period after 2015. Building on this idea, pre-treatment university performance can thus be associated with the formulas' outcome variables, leading to an endogenous effect. To eliminate the effect of pre-treatment performance on the extra funding and to increase the credibility of the parallel trend assumption, a reweighting technique based on the propensity scores of the untreated universities (that did not receive extra funds) is used.

Hence, to evaluate the causal effect of PBF on university performance, we implement a two-stage research strategy. During the first stage, we define and build the treatment and control groups by distinguishing universities on the basis of the financial resources they have received through PBF. The treatment group includes universities that started to receive greater public funding due to the PBF reform. During the second stage, the causal effect of the redistribution of public funds between universities due to PBF on university performance is estimated by means of the econometric technique of the semiparametric DID method, comparing the performance of the treated universities with that of their counterparts that did not experience such a funding increase. Sections 4.2.1 and 4.2.2 describe both steps, respectively, in greater detail.

This methodological strategy can be viewed as the best available option to evaluate the effect of PBF reform on university performance, as the policy design implies that all HEIs are treated simultaneously. The specific feature of the PBF policy that makes it possible to apply the methodology described below is that different organizations were treated differently—some organizations received extra funds, others did not. Although the methodology allows define treatment and control groups only *ex post* × *post* the intervention, the characteristics of universities were known *a priori* so that none of the universities had the ability to manipulate the results of the quasi-experiment.

4.2.1 Identifying the treatment and control groups The implementation of the new funding scheme resulted in the redistribution of public funding. After 2015, some universities gradually started receiving more public funding, while others were less successful. A university that obtained more public funding from year to year in 2015–8, that is, had a positive PBF trend, is called a 'winner' for the purposes of this study. In contrast, if a university obtained less and less PBF in 2015–8 than in previous periods, it is called a 'loser'. Some universities had an unstable PBF trend with no clear tendency towards winning or losing; we call them 'no-trend' universities.

Such a classification of universities in accordance with their PBF trends is required to build the treatment and control groups. For the purpose of this study, we regard treatment as gaining extra public funding after the implementation of the reform. Hence, *winning universities are the treatment group, as they experienced a continued increase in public funding*. Universities without a particular trend are the control group as the fluctuations in their public funding trends are close to zero. The group of losing universities cannot be taken as the control group, because they experienced a continued decrease of public funding, which may be considered as a negative treatment (or may be related to unobservable features that also affected performance). For this reason, after labelling universities as winners, losers, and no-trend universities, the empirical analysis examines only winning universities (treatment group), and no-trend universities (control group). Losing universities can be considered as organizations that experienced negative treatment; however, in the context of this study, we are only interested in determining how additional funding influences further performance. Therefore, we exclude losing universities from our analysis after classification.

We differentiate HEIs with the use of time series cluster analysis (Montero and Vilar, 2014). The idea of this technique is to determine universities with similar funding patterns in time and distinguish them into groups according to these funding trends. For example, universities with gradually increasing funding will belong to the same group while the university with decreasing funding will not get into this group. However, dynamic character of the data we employ requires specific way of comparing funding trends of universities. So called dissimilarity measures should be calculated. Hence, in the study, we estimate the dissimilarity measures of each pair of universities and then apply clustering algorithm to them.

There are two main approaches to measuring dissimilarity in time series data: shape-based, in which the local patterns of two datasets are compared, and structure-based, which takes the global structure of trends into account (Lin and Li, 2009; Montero and Vilar, 2014). Since the clustering objective is to show similar underlying structures (i.e. a positive/negative trend or the absence of any trend), the structure-based dissimilarity measure was chosen. Following Montero and Vilar (2014), we use Pearson's correlation-based distance between X_T and Y_T, which represent the time series of PBF given by Equation (1):

$$\mathrm{COR}(X_T, Y_T) = \frac{\sum_{t=1}^{T}\left(X_t - \overline{X}_T\right)\left(Y_t - \overline{Y}_T\right)}{\sqrt{\sum_{t=1}^{T}\left(X_t - \overline{X}_T\right)^2}\sqrt{\sum_{t=1}^{T}\left(Y_t - \overline{Y}_T\right)^2}} \quad (1)$$

where $\overline{X}_T$ and $\overline{Y}_T$ are the average values of the serial realizations of X_T and Y_T, respectively (in our case, they indicate the amount of funding received from the government). The logic of Equation (1) is close to that of the conventional correlation coefficient. Similar underlying structures of trends yield positive values, while opposite trends yield negative values. A lack of pronounced similarities/dissimilarities yields 0.

During the second stage, we use the k-means clustering algorithm (Hennig, 2015). This algorithm selects certain values as the centres of clusters (random centroids) and assigns other values to the closest centroids by using the Euclidean distances between them. During the second iteration, the centroid's new value becomes the mean of all the data points in the cluster. These iterations continue until the centroids stop moving (until the algorithm converges). The k-means clustering algorithm requires knowledge of the precise number of clusters. To validate the number of clusters proposed for the purposes of this study (the three groups of universities with positive, negative, and neither positive nor negative trends), we use the Elbow method.

4.2.2. Estimating the causal effect of the policy To establish causality between the increase in PBF and university performance in subsequent periods, we employ the DID estimator. This approach is widely used to evaluate the effect of policy intervention by comparing the variation over time of the outcome variable y between the treatment and control groups (Pedraja-Chaparro, 2016; Zong and Zhang, 2019). In our case, we assume that each university has two potential outcomes: y_{1t} if the university receives the treatment by time t, and y_{0t} otherwise. Taking d as an indicator of whether a university is treated ($d = 0$ at time $t = 0$; $d = 1$ for treated universities at time $t \neq 0$), one can estimate the average treatment effect on the treated universities by the equation

$$\text{ATT} \equiv E(y_{1t} - y_{0t}|d = 1) \tag{2}$$

Considering the reception of more resources from the government as the treatment, we calculate the effect of this increase on the set of performance indicators (outcome variables). These are the same indicators those used in the PBF formula (see Table 1): (i) average national entrance exam score (for both publicly funded places and tuition-funded places); (ii) number of publications in journals indexed by the Web of Science and Scopus per 100 academic staff; (iii) R&D income from extra-budgetary sources; (iv) total R&D income per academic staff member; (v) share of foreign students; and (vi) ratio of the average monthly salary of the university's academic staff to the regional average monthly salary. As Fig. 1 shows, the trends in one performance indicator—WoS publications per 100 academic staff members—were parallel before the introduction of the reform yet diverged afterwards. The same holds for other performance indicators of interest (Fig. 2).

The conventional parametric DID estimator strongly depends on the assumption of a parallel trend, which implies that, in the absence of treatment, the outcome variables would have followed the same trend in the treatment and control groups. However, in our quasi-experimental design, the selection for the treatment is not random but pre-determined by a performance-based multi-factor formula. Hence, it is possible that performance in the pre-treatment period could be a source of an additional variation in the outcome variables and, as a result, cause bias in the effect estimates (endogeneity). To obtain an unbiased estimate of the treatment effect, the semiparametric DID estimator developed by Abadie (2005) is used.

Let us define x_b as the set of pre-determined characteristics in the baseline, $\Delta y_t = y_t - y_b$ as the change in an outcome variable between time t and the baseline b, and $\pi(x_b) = P(d = 1| x_b)$ as the conditional probability of being treated, that is, the propensity score. The idea of Abadie (2005) is that the equation

$$E\left(\frac{\Delta y_t}{P(d = 1)} \times \frac{d - \pi(x_b)}{1 - \pi(x_b)}\right) \tag{3}$$

makes an unbiased estimate of the average treatment effect on the treated if Equations (4) and (5) hold:

$$E(y_{0t} - y_{0b}|d = 1, x_b) = E(y_{0t} - y_{0b}|d = 0, x_b) \tag{4}$$

$$\pi(x_b) < 1 \text{and} P(d = 1) > 0 \tag{5}$$

To sum up, this method applies weightings to changes in the outcome variable (Δy_t) between the baseline and subsequent periods for the untreated based on their propensity scores, which are approximated semiparametrically by the use of the series logit estimator (Hirano *et al.*, 2003), and then compares these weighted changes across the treatment and control groups. This approach also helps to avoid estimation errors arising from functional misspecification related to the use of a non-parametric estimator.

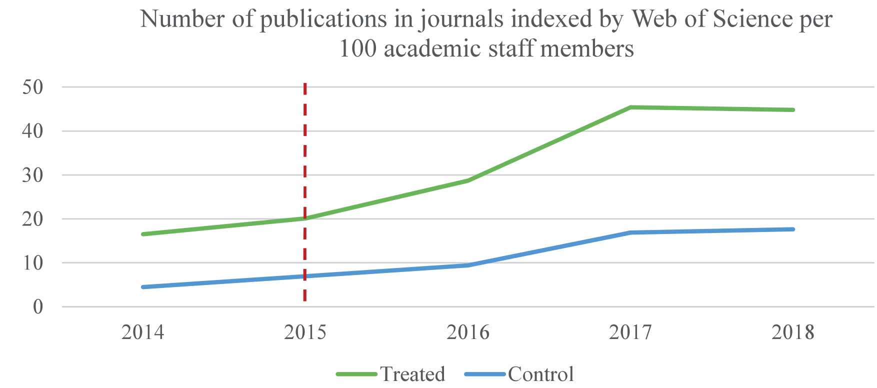

Fig. 1. Number of publications in journals indexed by the Web of Science per 100 academic staff members for treated and control universities before and after treatment.
Source: authors' calculations using data provided by HEI Performance Monitoring, MoES.

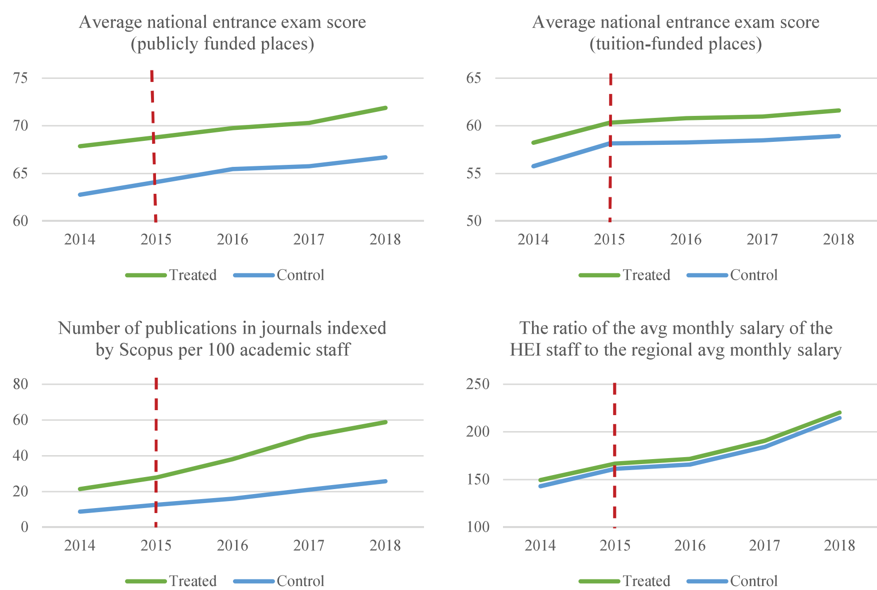

Fig. 2. Performance indicators (used in the formula) for treatment and control universities before and after treatment.
Source: authors' calculations using data provided by HEI Performance Monitoring, MoES.

We assume that the increase of PBF does not affect every university in the same way and on the same scale (the effect depends, in particular, on the specific observable and unobservable features of each university). The semiparametric DID estimator allows the treatment effect to vary among universities with changes in covariate values, thus controlling for potential non-linearities of the effect. Our particular version of the empirical model accounts for the possibility that the treatment effect may vary with the share of PBF (indicating the degree of dependence on the state). In so doing, our empirical estimations control for the influence of the PBF share (in the total budget) on subsequent performance indicators.

4.3 Description of variables

Using Abadie's (2005) method, we consider the changes in 2014–8 in the performance indicators employed in the formula as the outcome variables. The full list of the specific performance indicators is given in Table 2, along with the methodology for their calculation. Different studies treat some of these variables (e.g.USE scores and share of international students) differently—as either inputs or outputs. However, since the government includes all indicators from Table 2 in the formula as outcome variables and takes the values of these indicators into account during the allocation process, we adhere to its logic and consider them as output variables.

The universities in the sample clearly differ in performance. Some of them show higher values of performance indicators as well as higher growth rates of these indicators. This leads to unbalanced chances of treatment (i.e. obtaining extra funding) for universities with different absolute values of the performance indicators used in the PBF formula or with different implicit quality characteristics. We overcome the potential bias of the estimations by controlling for the individual characteristics of universities that might be associated with variations in the outcomes. In particular, in addition to performance indicators during the pre-treatment year (2014), which capture some unobserved heterogeneity in the universities' resources before the policy was introduced, we also control for the number of FTE students and the total income of a university. These two variables represent specific dimensions of university activities (university size and overall resources available) that might be potentially correlated with the level of performance and its dynamics over time. Controlling for these factors helps to avoid the misattribution of changes in performance to the effect of the policy.

Our assumptions about the heterogeneity of the policy effect go even further. We hypothesize that universities with different characteristics may be affected differently. Specifically, universities with different shares of the PBF in the total income (i.e. a different level of dependence on the state) may experience different treatment intensities. We also assume that universities, which are actively involved in government programmes[4] and consequently obtain extra special-purpose funding from the state may be affected differently than universities that do not participate in such programmes. Thus, our empirical analysis controls for university status. *Leading* status means that a university is either a federal university, a national research university or a university that is participating in the 5–100 Project. If none of these holds, the university has *regional* status.

4 These include federal universities (10 universities), national research universities engaging in advanced research (29 universities), and universities participating in the Russian excellence initiative Project 5–100 (2012) (21 universities, the vast majority of which are federal and national research universities).

5. Results of empirical analysis

5.1 Identifying winners and losers—preliminary descriptive evidence

Sixty-seven winners, 72 losers, and 75 universities without any trends in funding over 4 years were identified using the time series clustering method. The descriptive statistics of the outcome variables and covariates employed in the semiparametric DID estimation are presented in the Table 3, which provides a comparison between the mean values of the treatment and control groups. The last column shows the difference between these means, along with *t*-tests for unequal variances.

Despite the fact that the winners demonstrate higher values of the performance indicators employed in the formula, changes in performance between 2014 and 2018 differ little between the treatment and control groups on the whole. This evidence suggests that differences in absolute performance may stem from structural differences before the implementation of the policy, which is consequently not clearly linked to any radical change of performance. The only exception is changes in the number of WoS and Scopus publications per 100 academic staff. For this indicator, it seems that the policy could have exerted some kind of effect by changing the performance trajectory for the treated ('winning') universities.

There is also a major distinction between the treatment and control groups when considering educational programmes. The winning universities have higher shares of education programmes in engineering, industrial sciences, mathematics, and natural sciences, while the control (no-trend) universities have more agricultural and teacher training programmes. This distinction exists because of the cost differences between fields of study. Engineering and technical education programmes require more sophisticated material infrastructure and complex laboratory equipment than teacher training programmes.

5.2 Trends in outcome variables

Figure 2 presents the performance indicators used in the formula and compares the average values of the treatment and control groups over time. Six out of eight indicators show parallel trends before treatment (dotted lines). Exceptions to these parallel trends are (i) the R&D income from extra-budgetary sources per academic staff member and (ii) the total R&D income per academic staff member. The extra-budgetary R&D income trend for the treatment group is negative throughout the whole period, while the trend of the same indicator for the control group is slightly positive though fluctuating. The total R&D income of the treatment group decreased in 2015 in comparison with 2014, yet the trend direction subsequently changed and, in 2018, the value of the indicator returned to its 2014 level. While the descriptive analysis seems to indicate the absence of any clear effect of the PBF policy, a rigorous evaluation of this effect is made in the next paragraph, where a proper econometric approach is implemented as indicated in Section 4.2.

5.3 Impact of the policy on university performance

Table 4 presents estimates of the effect of being a 'winner' after the introduction of PBF on performance indicators of universities under MoES authority. We run different models to check the sensitivity of the results to alternative specifications. All models control for the absolute values of performance indicators in 2014. Models (1) and (2) are estimated using the whole sample, while Models (3) and (4) are estimated using a subsample of regional universities (Moscow and St Petersburg universities are excluded). Models (1) and (3) give

Table 3. Characteristics of universities under MoES authority, treatment, versus control group

Variable	Entire sample	Treated	Non-treated	Difference
Share of treated	0.47			
	[0.5]			
Outcome variables:				
Change from 2014 to 2018:				
Average USE score (publicly funded places)	3.97	4.03	3.92	0.11
	[3.46]	[3.05]	[3.81]	(0.58)
Average USE score (tuition-funded places)	3.26	3.38	3.15	0.23
	[4.71]	[4.11]	[5.21]	(0.79)
WoS publications per 100 academic staff members	20.33	28.34	13.17	15.17***
	[30.75]	[42.44]	[9.23]	(5.29)
Scopus publications per 100 academic staff	26.65	37.44	17.02	20.42***
	[38.43]	[52.02]	[14.19]	(6.56)
Share of foreign students	2.82	2.58	3.04	−0.46
	[4.54]	[4.39]	[4.69]	(0.76)
Extra-budgetary R&D income per academic staff member, thousand roubles	96.22	120.38	74.64	45.74
	[374.29]	[506]	[193.86]	(65.74)
Total R&D income per academic staff member, thousand roubles	59	61.36	56.9	4.46
	[401.12]	[505.25]	[280.86]	(69.73)
Salary ratio	71.27	70.97	71.54	−0.57
	[25.69]	[31.55]	[19.23]	(4.44)
Covariates:				
Share of education programmes in				
Mathematics and natural sciences	0.07	0.09	0.05	0.04**
	[0.11]	[0.14]	[0.06]	(0.02)
Engineering and industrial sciences	0.42	0.48	0.37	0.11**
	[0.33]	[0.31]	[0.34]	(0.06)
Medicine	0.01	0.01	0.02	−0.01
	[0.05]	[0.04]	[0.06]	(0.01)
Agriculture	0.01	0.01	0.02	−0.01
	[0.04]	[0.01]	[0.06]	(0.01)
Social sciences and humanities	0.3	0.34	0.27	0.07**
	[0.2]	[0.21]	[0.19]	(0.03)
Teacher training	0.16	0.05	0.26	−0.21***
	[0.28]	[0.12]	[0.34]	(0 .04)
Arts and culture	0.02	0.02	0.01	0.01
	[0.04]	[0.05]	[0.04]	(0.01)
Performance indicators in absolute values in 2014:				
Number of students in FTE	6,500.69	7,304.30	5,782.80	1,521.50**
	[3,915.22]	[4,229.64]	[3,484.97]	654.93
Total income, thousand roubles	1,756,425.08	2,314,888.78	1,257,530.84	1,057,357.94***
	[1,881,677.11]	[2,158,837.46]	[1,433,567.05]	(311,387.9)
Average USE score (publicly funded places)	65.17	67.86	62.77	5.09***
	[6.95]	[7.69]	[5.18]	(1.11)
	56.93	58.24	55.76	2.48***

(continued)

Table 3. Continued

Variable	Entire sample	Treated	Non-treated	Difference
Average USE score (tuition-funded places)	[5.34]	[5.72]	[4.73]	(0.89)
WoS publications per 100 academic staff members	10.15	16.49	4.49	12***
	[20.24]	[27.96]	[3.8]	(3.44)
Scopus publications per 100 academic staff members	14.66	21.35	8.69	12.66***
	[20.97]	[28.23]	[7.13]	(3.55)
Share of foreign students	5.19	6.03	4.44	1.59*
	[4.81]	[4.94]	[4.59]	(0.80)
Extra-budgetary R&D income per academic staff member, thousand roubles	219.65	340.78	111.45	229.33***
	[300.06]	[382.88]	[125.15]	(48.96)
Total R&D income per academic staff member, thousand roubles	391.67	584.14	219.72	364.42***
	[538.84]	[678.59]	[281.1]	(89.03)
Salary ratio	146.07	149.41	143.09	6.32
	[30.09]	[37.69]	[20.95]	(5.20)
Additional indicators and dummies				
PBF share	0.36	0.32	0.39	−0.07***
	[0.09]	[0.09]	[0.09]	(0.01)
Leading status of university	0.18	0.31	0.07	0.25***
	[0.39]	[0.47]	[0.25]	(0.06)
Moscow/St Petersburg location	0.23	0.42	0.07	0.35***
	[0.42]	[0.5]	[0.25]	(0.07)
Number of universities	142	67	75	142

Note: Standard deviations in brackets, standard errors in parentheses, and significance levels denoted as follows:
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.
Source: authors' calculations using data provided by HEI Performance Monitoring, MoES.

estimates of the average treatment effect on the treated (ATT). Models (2) and (4) show how the average treatment effect varies with the share of PBF in the total funding of the university, the status of the university (leading = 1 or regional = 0) and the location of the university (Moscow or St Petersburg = 1, otherwise = 0). In addition, Models (3) and (4) compare the average treatment effect between leading and regional universities.

Starting with the simplest Model (1), extra funds resulting from PBF introduction have a positive effect on six out of eight performance indicators: average USE score (for both publicly and tuition-funded places), number of WoS, and Scopus publications per 100 academic staff, share of foreign students, and salary ratio. In particular, the policy effect appears to have generated an increase in the average USE scores by 1.55 points for publicly funded places and 1.8 points for tuition-funded places in 2018. Universities started to pay more attention to the abilities of their enrolees with the aim of attracting more public funds through PBF. When heterogeneity is taken into account, the effect of extra funding on average USE scores decreases as the share of PBF in the total income of a university increases—see Model (2). Universities located in Moscow or St Petersburg show a higher effect of extra funding on average USE scores in comparison to universities in other regions. The leading

Table 4. Causal impact of the policy: the effect of being a 'winner' on the performance indicators of universities under MoES authority

Outcome variable		(1)	(2)	(3)	(4)
Average USE score (publicly funded places)	ATT	1.549**	5.589	−0.297	11.37***
		(0.753)	(3.898)	(0.756)	(4.394)
	PBF share		−17.41*		−32.18***
			(10.41)		(12.08)
	Leading status		2.288		
			(1.948)		
	Moscow/St Petersburg location		2.183		
			(1.494)		
Average USE score (tuition-funded places)	ATT	1.797***	5.840**	−0.953	7.345*
		(0.661)	(2.971)	(0.971)	(4.294)
	PBF share		−19.09**		−22.90*
			(8.548)		(12.64)
	Leading status		2.978**		
			(1.278)		
	Moscow/St Petersburg location		2.975**		
			(1.247)		
Share of foreign students	ATT	1.179*	0.902	0.641	3.925
		(0.645)	(3.040)	(1.029)	(4.589)
	PBF share		−1.136		−9.064
			(9.005)		(12.34)
	Leading status		2.921**		
			(1.180)		
	Moscow/St Petersburg location		−0.644		
			(1.126)		
WoS publications per 100 academic staff members	ATT	17.07***	18.68	−2.888	11.11
		(6.242)	(24.39)	(4.312)	(29.26)
	PBF share		−80.40		−38.64
			(63.07)		(72.53)
	Leading status		49.94***		
			(12.96)		
	Moscow/St Petersburg location		21.37**		
			(10.47)		
Scopus publications per 100 academic staff members	ATT	22.69***	25.70	−3.751	40.82
		(7.667)	(26.56)	(3.379)	(25.40)
	PBF share		−113.8		−123.0*
			(72.28)		(68.50)
	Leading status		63.60***		
			(15.42)		
	Moscow/St Petersburg location		33.76***		
			(12.38)		

(continued)

Table 4. Continued

Outcome variable		(1)	(2)	(3)	(4)
Salary ratio	ATT	24.99***	12.78	−3.166	97.27
		(8.475)	(51.17)	(5.358)	(61.65)
	PBF share		−68.67		−277.1
			(139.6)		(169.6)
	Leading status		20.73		
			(20.45)		
	Moscow/St Petersburg location		67.20***		
			(15.42)		
Extra-budgetary R&D income per academic staff member	ATT	54.59	−376.8	11.08	−28.40
		(67.44)	(240.6)	(38.65)	(197.8)
	PBF share		636.2		109.0
			(628.7)		(518.7)
	Leading status		530.3***		
			(169.2)		
	Moscow/St Petersburg location		138.6		
			(133.0)		
Total R&D income per academic staff member	ATT	−9.552	−464.0*	−39.14	−48.61
		(69.73)	(253.6)	(53.36)	(250.2)
	PBF share		758.1		26.15
			(625.2)		(624.1)
	Leading status		526.0***		
			(177.3)		
	Moscow/St Petersburg location		102.0		
			(137.3)		
Number of universities		142	142	96	96

Note: All effects are estimated by using a logit specification to estimate the propensity score.
Standard errors in parentheses; significance levels denoted as follows:
***$p < 0.01$.
**$p < 0.05$.
*$p < 0.1$.
Source: authors' calculations using data provided by HEI Performance Monitoring, MoES.

status of a university also gives a few more points in performance compared to regional universities. However, this effect is observed only for average USE scores for tuition-funded places. The effect is not statistically significant for both types of USE scores in Model (3), which is estimated on a subsample of non-leading universities located in regions other than Moscow and St Petersburg. In Model (4), which accounts for university heterogeneity in terms of the PBF share in the total university income, the effect becomes statistically significant once again and can be interpreted as follows. For the average public university with a PBF share equal to approximately one-third of its total income, getting extra funds increases average USE scores by 1.72 points for publicly funded places and by 0.5 points for tuition-funded places. In contrast, for a university with the PBF share equal to 20%, the increase in USE scores is estimated at 4.93 and 2.76 for publicly funded and tuition-funded places, respectively.

Getting extra funds also leads to an increase in the share of foreign students by almost 1.2% and the number of WoS and Scopus of publications by 17 and 22 publications per 100 academic staff members, respectively. One can identify a potential channel of the effect of extra funds on the share of foreign students. Indeed, it might be the case that, once a university gets extra funds, it starts to invest more in its reputation—for example, by developing academic mobility programmes, establishing contacts with foreign universities and professors, and attracting international students. As to the impact of the policy on the number of publications, there are three main possible explanations. The first is that some papers were on track before the policy was implemented; so, attributing this effect to the policy would be misleading. The second is that, in order to increase the number of publications within a year significantly, universities started to publish in lower quality journals with higher acceptance rates (again, the effect would not be in line with the reform's purpose). The third potential explanation is that universities were able to leverage resources towards higher research productivity—for example, by providing incentives to their tenured staff or employing productive international scholars.

In Model (1), there is also no statistically significant effect of getting extra funds on the amount of R&D income per academic staff member. The result seems reasonable since PBF aims to cover university tuition costs. However, in Model (2), there is a significant positive effect of being a leading university on the amount of R&D income per capita. This shows that leading universities either manage their funds in a more efficient way or have better resources (financial and human) in terms of both quality and quantity.

In conclusion, our major finding is that, if we look beyond the baseline results from Model (1) and proceed to the more specific Models (2), (3), and (4), we observe that the policy effect is statistically significant only for leading universities and for universities located in the Moscow and St Petersburg regions. Indeed, the effect of PBF on the subsample of regional universities is not statistically significant. Such heterogeneity corroborates the idea that the policy can be effective only upon the condition of the existence of specific characteristics of the treated universities, which has specific policy implications (see Section 6).

6. Discussion and concluding remarks

Our results show that the introduction of PBF has a positive and statistically significant effect on almost all performance indicators that are included in the funding formula. In other words, universities that receive extra funds due to PBF demonstrate greater performance gains. Given that the performance indicators of universities that started to receive less funding from the state or preserved the same level of funding did not decline, we can conclude that the PBF reform made it possible to redistribute the public funding of universities in such a way as to benefit the performance of the whole HE system. At the same time, controlling for the status of a university and its location shows that these characteristics somehow contribute to this effect, meaning that the policy can have a significant impact only in a heterogeneous way, benefiting leading universities and universities located in the Moscow or St Petersburg areas. The main short-term effect of the policy that is statistically significant after controlling for HEI characteristics relates to average national exam scores. From a policy perspective, this result indicates that PBF clearly encourages universities to be more selective in enrolling students. However, only universities with certain features (leading status, location, and relatively low share of PBF in the total income) were able to take actions that led to an improvement in performance (selectivity).

One of our key findings is that the treatment effect on performance (i.e. exam scores) decreases with an increasing PBF share in university budgets. This requires more detailed discussion. A likely explanation is that a high share of non-public funding (i.e. the ability of a university to attract external funding) can be considered as a proxy for good university management—specifically, the management of student admission campaigns. For example, the share of non-public funding at leading Russian universities is 2–3 times higher than the average across all public universities. Thus, additional public funding provided to universities with high-quality management (universities with a high share of resources from non-public sources) may lead to a greater increase in output due to more efficient resource use.

On the whole, the reform's structure stimulated a competitive environment and created additional incentives for universities to improve their performance indicators, precisely because the amount of public funding was tied to performance (see the theoretical discussion in Supplementary Appendix). However, the mechanism behind this effect may have also produced negative side effects. In particular, the redistribution of public funding across universities may have led to a further polarization of the HE system in terms of performance, a consequence that was surely not intended by policy makers. Universities with higher performance obtain more governmental resources and thus more opportunities to convert them into still higher outputs. Low-performing universities, on the contrary, receive fewer resources and may have no chance to invest in their development and improve performance in the future. Moreover, the observed effect is more evident in the domain of publication activity than in the domain of internationalization and exam scores. One may conjecture that universities can provide both monetary and non-monetary incentives to faculty to stimulate greater efforts and results in publication activity, while the technology of increasing the proportion and selectivity of the international student body is less evident. For example, the average share of non-Commonwealth of Independent States students has increased only by 1.5 p.p. between 2014 and 2018.

It is also interesting to discuss why the policy has had no effect on performance for some universities. There are several possible explanations for the fact that non-leading universities fail to convert extra funding into significant performance improvement. First of all, universities in Russia have other governmental requirements to satisfy besides PBF criteria. For example, Presidential Order no. 599 of 2012 specified that the ratio of the average monthly salary of university academic staff to the average regional monthly salary had to attain 200% by 2018. At the same time, Governmental Decree no. 234 established the student–faculty ratio at 12:1. Generally speaking, such multidimensional regulations and constraints make it difficult for university management to maximize performance and/or respond to specific incentives.

Our findings about the effects of introducing PBF in Russian HE generally corroborate the evidence from other countries. Existing research about the USA also demonstrates that PBF introduction increases selectivity (e.g. Birdsall, 2018). Researchers' publication activity has also increased, which corroborates existing empirical evidence from, say, Finland (Mathies *et al.*, 2020), Slovakia (Pisár and Šipikal, 2017), and Norway (Aagaard *et al.*, 2015) and generally agrees with the positive effect of performance-based practices on research output (Dougherty and Natow, 2020). However, we should note that our study says nothing about the quality of publications due to the limitations of our data. Finally, PBF disproportionately benefits well-performing institutions that are already receiving greater resources and thus increases stratification in the system. The effect of creating ‘winners’ and ‘losers’ was found for similar funding schemes in the UK (e.g. Morgan, 2004), the USA (Hagood, 2019; Favero and Rutherford, 2020), and several European countries (Dougherty and Natow, 2020).

In conclusion, we can formulate two potential policy implications. First, together with the constant underfinancing of HE (Abankina *et al.*, 2018), the stratifying potential of the current design of the PBF mechanism enhances the risks of the system’s bifurcation into multitask elite universities that are able to diversify their resource base and teaching institutions that are completely dependent on state funding. The latter organizations will run a greater risk of merger or closure due to their low performance (Agasisti *et al.*, 2020) arising from the decline in disposable resources. A potential way of minimizing such risks would be to change the extent to which state funding depends upon institutional performance for small and regional universities. Secondly, the increase in institutional stratification can produce unintended social consequences: existing research demonstrates that PBF introduction contributes to lowering access to HE for socio-economically disadvantaged groups (Ortagus *et al.*, 2020). Given the growing inequality of access to HE (Malinovskiy and Shibanova, 2019), introducing equity measures in the funding mechanism and increasing the existing coefficients for HEIs with regional status would be a good idea.

This study has some limitations that pave the way for future research. First of all, organizational changes triggered by the introduction of PBF require time (Manning, 2017). This is especially true when considering potential effects on research productivity growth. Our analysis is limited to short-term effects, as the reform was launched only in 2015. Additional studies must be implemented in upcoming years to assess PBF effects in the medium and long term. Secondly, we do not consider private universities and HEIs that are not under MoES authority, and thus our results cannot be generalized to the entire Russian HE system. Finally, another intrinsic limitation of the study is due to the complex design of the PBF reform—more specifically, its phased implementation: only first-year students were financed by PBF in 2012, first and second-year students in 2013, and all students only in 2015. We consider 2015 to be the first year when the treatment occurred, insofar as the universities in our sample started to be completely financed according to the new scheme only in 2015; as a result, potential pre-reform differences can affect the results of the assessment. However, we overcome this difficulty by showing that the assumption of pre-reform parallel trends between the control and treatment group actually holds.

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Supplementary material

Supplementary material is available on the OUP website. These are the data, Stata and R scripts, and the Supplementary appendix referred to in the main text.

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